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Advances in Thermal Infrared Mapping of Volcanic Sulfur Dioxide Plumes

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The current tools for estimating the sulfur dioxide (SO₂) concentrations of volcanic plume from multispectral thermal infrared (TIR) imagery were developed using data acquired from aircraft flying at altitudes less than 10 km. The advent of MODIS and ASTER TIR observations from space presents new challenges for the plume mapping procedures. The original mapping tools have been updated and modified to address these challenges.

Airborne remote sensing experiments have demonstrated that atmospheric water vapor is variable on spatial scales as small as 25 m. Despite this high potential for variation, the conventional practice in plume mapping has been to assume that the distribution of water vapor can be characterized with a few radiosonde measurements or single climatological model. This assumption is not valid for MODIS TIR data, which have a spatial resolution of 1 km (at nadir) and swath width of 2300 km. ASTER TIR data have higher spatial resolution (90 m at nadir) than MODIS data, but the width of an ASTER swath (60 km) ensures that there will be variations in water vapor within a scene. To address the challenge of characterizing the variations in water vapor, we have developed a technique to estimate the water vapor abundance on a pixel-by-pixel basis. This technique will also be used to characterize the distribution of ozone in the atmosphere.

The observations of volcanic plumes from low-altitude aircraft are typically confined to areas near the source vents and the conventional practice has been to assume that the unique radiometric signatures of plumes can be attributed to SO₂ gas. By providing synoptic views of entire plumes and clouds, MODIS and ASTER increase the likelihood that sulfate aerosols are present in the scene. The radiative transfer model used in the plume mapping procedure does not provide much flexibility with regards to aerosol size distribution, number density, and composition.

To address the issues of mapping sulfate aerosols in addition to SO₂ gas, we now isolate the radiative emission and absorption due to the plume from that of the rest of the atmosphere. This new strategy gives us explicit control over the aerosol parameters used in the radiative transfer calculations and allows us to model the combined effects of aerosols and gas. This modeling technique will be extended to silicate ash particles, water droplets, and ice particles.

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